(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 December 2001 (27.12.2001)

PCT

(10) International Publication Number
WO 01/98066 A1

(51) International Patent Classification[7]: B29D 11/00, B29C 59/04

(21) International Application Number: PCT/US01/18655

(22) International Filing Date: 8 June 2001 (08.06.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/596,240 16 June 2000 (16.06.2000) US
09/781,756 12 February 2001 (12.02.2001) US

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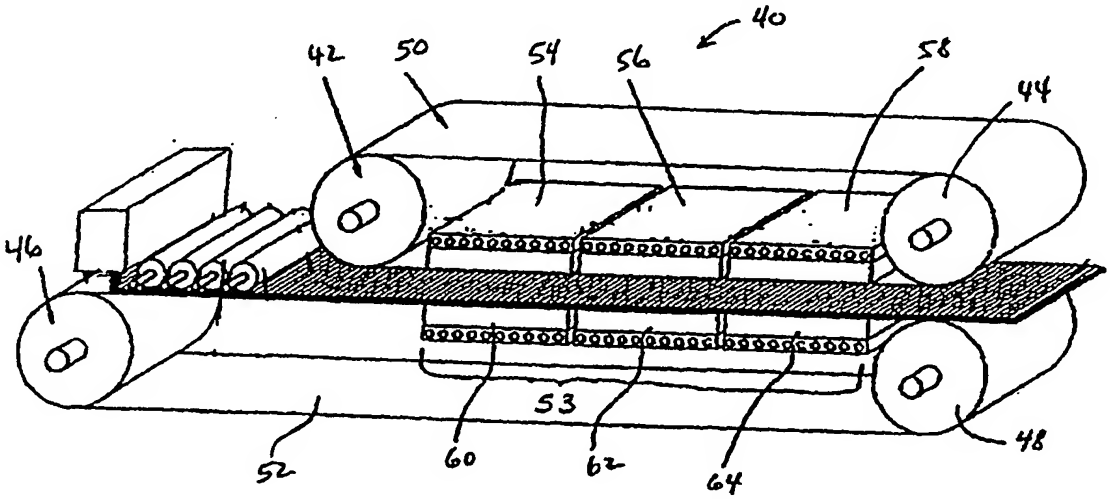
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A PROCESS AND APPARATUS FOR PRECISE EMBOSSING



(57) Abstract: A process and apparatus for forming thermoplastic products having precise embossed surfaces including using a continuous press (40) having upper and lower belts (50, 52) with the embossing patterns thermoplastic material through the press (40) where heat and pressure are applied and thereafter cooling the material while maintaining pressure in a reaction zone (53). Pressure is maintained at about 250 psi, heating is at about 480 °F and cooling is at about 35 °F.

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A PROCESS AND APPARATUS FOR PRECISE EMBOSSING

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

The present invention relates to a process and apparatus for embossing material with precise detail, and more particularly, to a process and apparatus for making products of thermoplastic material having surfaces with precise indentations.

BACKGROUND ART

Processes and apparatus for embossing precision optical patterns, often called microcubes, in a resinous sheet or laminate is well known, as referenced in U.S. Patents Nos. 4,486,363; 4,478,769; 4,601,861; 5,213,872; and 6,015,214, which patents are all incorporated herein by reference. By way of example, thin flexible thermoplastic material may be embossed with precision patterns where flatness and angular accuracy are very important. Products that require such accuracy include, for example, retroreflective materials for road reflectors or signage. As described in some of the above mentioned patents, the sheeting may be made on a machine that includes two supply reels, one containing an unprocessed web of thermoplastic material, such as acrylic or polycarbonate or even vinyl, and the other containing a transparent plastic carrier film such as Mylar. These are fed to an embossing tool which may take the form of a thin endless metal belt.

The belt moves around two rollers which advance the belt at a predetermined linear speed or rate. One of

the rollers is heated and the other roller is cooled. An additional cooling station may be provided between the two rollers. Pressure rollers are arranged about a portion of the circumference of the heated roller. Embossing occurs on the web as it passes around the heated roller and while pressure is applied. The embossed, now laminated sheeting, is cooled, monitored for quality and then moved to a storage winder. Before shipping the Mylar film may be stripped away from the embossed film.

Continuous press machines are also well known to those skilled in the art. These include double band presses which have continuous flat beds with two endless bands or belts, usually steel, running above and below the product and around pairs of upper and lower drums or rollers. These form a pressure or reaction zone between the two belts and have the advantage that pressure is applied to a product when it is flat rather than when it is in a curved form. The double band press also allows pressure to vary over a wide range and the same is true of temperature variability. Dwell time or time under pressure is also easily controllable by varying the production speed or rate, as is capacity which may be changed by varying speed and/or length and/or width of the press.

In use, the product is "grabbed" by the two belts and drawn into the press at a constant speed. At the same time, the product, when in a relatively long flat plane, is exposed to pressure in a direction normal to the product. Of course, friction is substantial on the product but this may be overcome by one of three systems. One system is the gliding press, where

pressure-heating plates are covered with low-friction material such as polytetrafluorethylene and lubricating oil. Another is the roller bed press, where rollers are placed between the stationary and moving parts of the press. The rollers are either mounted in a fixed position on the pressure plates or incorporated in chains or roller "carpets" moving inside the belts in the same direction but at half speed. The roller press is sometimes associated with the term "isochoric". This is due to the press providing pressure by maintaining a constant distance between the two belts where the product is located. Typical isochoric presses operate to more than 700 psi.

The third press type is the fluid or air cushion press which uses a fluid cushion of oil or air to reduce friction. The fluid cushion press is sometimes associated with the term "isobaric" and these presses operate to about 1000 psi. Pressure on the product is maintained directly by the oil or the air. Air has the advantage of providing a uniform pressure distribution over the entire width and length of the press.

Heat is transferred to thin products from the heated rollers or drums via the steel belts. With thicker products heat is transferred from heated pressure plates to the belts and then to the product. In gliding presses, heat is also transferred by heating the gliding oil itself. In roller bed presses, the rollers come into direct contact with the pressure-heating plates and the steel belts. With air cushion presses, heat flows from the drums to the belts to the product, and, by creating a turbulence in the air cushion itself, heat transfer is

accomplished relatively efficiently. Also, heat transfer increases with rising pressure.

Another advantage of the double band press is that the product may be heated first and then cooled with both events occurring while the product is maintained under pressure. Heating and cooling plates may be separately located one after the other in line. The steel belts are cooled in the second part of the press and these cooled belts transfer heat energy from the product to the cooling system fairly efficiently.

Continuous press machines fitting the description provided hereinabove are sold by Hymmen GmbH of Bielefeld, Germany (U.S. office: Hymmen International, Inc. of Duluth, Georgia) as models ISR and HPL. These are double belt presses and also appear under such trademarks as ISOPRESS and ISOROLL. Typically they have been used to produce relatively thick laminates, primarily for the furniture industry.

Even though embossing of thermoplastic is known, improvements are still needed to increase manufacturing efficiency, improve quality and lower the cost of finished products.

DISCLOSURE OF THE INVENTION

The present invention offers numerous advantages and relates to a process and apparatus for making thermoplastic products having precise embossed surfaces comprising the steps of providing a continuous press with an upper set of rollers, a lower set of rollers, an upper belt disposed about the upper set of rollers, a lower belt disposed about the lower set of rollers, a heating station, a cooling station and

pressure producing elements, passing a thermoplastic material through the press, heating the material to about 480° F., applying pressure of about 250 psi to the material, cooling the material to about 35° F., and maintaining pressure on the material when the material is cooled.

An object of the present invention is to provide a process and apparatus for efficiently, effectively, and inexpensively embossing thermoplastic material with precise detail.

A more complete understanding of the present invention and other objects, aspects, aims and advantages thereof will be gained from a consideration of the following description of the preferred embodiment read in conjunction with the accompanying drawings provided herein.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a diagrammatic view of a prior art embossing machine.

FIGURE 2 is a diagrammatic isometric view of a double band press for making embossed product.

FIGURE 3 is a flow chart of the process for making embossed product.

BEST MODE FOR CARRYING OUT THE INVENTION

While the present invention is open to various modifications and alternative constructions, the preferred embodiment shown in the drawings will be described herein in detail. It is understood, however, that there is no intention to limit the invention to the particular form disclosed. On the contrary, the

intention is to cover all modifications, equivalent structures and methods, and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring now to FIGURE 1, there is illustrated an existing embossing machine in diagrammatic form including a first heated roller 10, a second cooled roller 12, a steel embossing belt 14 running around the rollers, a cooling station 16 and four pressure rollers 18, 20, 22 and 24. In practice the heated roller 10 is about twenty-one inches in diameter. The pressure rollers are about eight inches in diameter and each applies a pressure of about 250 psi when retroreflective sheeting is being manufactured. The temperature of the heated roller is about 480° F. Since the pressure rollers are somewhat deformable, there is a reaction zone - where both heat and pressure are applied to the thermoplastic material - of about one inch in length and sixty inches in width for each of the pressure rollers. The total heat/pressure reaction zone is four inches by sixty inches. There is another reaction zone where the material passes the cooling station 16. If the cooling station is twelve inches long then that is the length of the second reaction zone. With the dimensions just given, the embossing process may progress at a rate of about three to four feet per minute.

Referring now to FIGURE 2, a continuous press is illustrated. The press 40 includes a pair of upper rollers 42, 44 and a pair of lower rollers 46, 48. The upper roller 42 and the lower roller 44 may be oil heated. Typically the rollers are about 31.5 inches in diameter and extend for about 51 inches. Around each

pair of rollers is a steel belt, an upper patterned belt 50 is mounted around the upper rollers 42, 44 and a lower patterned belt 52 is mounted around the lower rollers 46, 48. Heat and pressure are applied in a portion of the press referred to as the reaction zone 53. Within the reaction zone are means for applying pressure and heat, such as three upper matched pressure sections 54, 56, 58 and three lower matched pressure sections 60, 62, 64. Each section is about 39 inches long and approximately 51 inches wide. Heat and pressure may be applied by other means as is well known by those skilled in the press art. Also, it is understood that the dimensions set forth are for existing continuous presses, such as those manufactured by Hymmen; these presses may be enlarged if found desirable.

The lower belt 52 may be smooth if only one side of a product is to be embossed. If both sides of the product are to be embossed, then both the upper belt 50 and the lower belt 52 will bear embossing patterns. It is to be understood that the pressure sections may be heated or cooled. Thus, for example, the first two upstream pressure sections, upper sections 54, 56 and the first two lower sections 60, 62 may be heated whereas the last sections 58 and 64 may be cooled or maintained as a relatively constant but lower temperature than the heated sections.

It is contemplated that thermoplastic material such as acrylic, polycarbonate, vinyl, polyethylene, ABS and polyurethane may be used in the press 40. With such material the pressure range is approximately 150 to 400 psi and the temperature range is approximately 250° to 580° F. Material thicknesses of up to 0.250 inches may

be embossed with indentations in the range of 0.002 to 0.010 inches deep.

It is desirable that the material, after being exposed to heat and pressure, be cooled under pressure. Thus, it is contemplated that the cooling station will be maintained in the range of 32° to 40° F. and the pressure range approximately 150 to 400 psi.

The process for forming thermoplastic products having precise indentations or embossments is illustrated in FIGURE 3 and includes providing a continuous press 100, passing 102 a thermoplastic material through the press, heating 104 the material to about 480° F., applying pressure 106 of about 250 psi to the material, cooling 108 the material at the cooling station which is maintained at about 35° F. and maintaining a pressure 110 of about 250 psi on the material during the cooling step.

With the dimensions and reaction zones stated above, the process rate may move at about 21 to 32 feet per minute, roughly 7 to 8 times the rate of prior art machines.

The apparatus of the present invention allows for thermoplastic material to be relatively thick and yet still have precision indentations in one or both major surfaces. This allows products as diverse as office light diffusers, reflective signage, compact disks, flat panel displays, high-efficiency lighting systems for internally illuminated signs and medical diagnostic products to be efficiently, effectively and inexpensively manufactured.

The specification describes in detail an embodiment of the present invention. Other modifications and variations will, under the doctrine of equivalents,

come within the scope of the appended claims. For example, presses having somewhat different geometries and/or different dimensions are considered equivalent structures. Different material may affect pressure and temperature as well as process speed. Further, different material densities and thicknesses may also affect the apparatus and process. Still other alternatives will also be equivalent as will many new technologies. There is no desire or intention here to limit in any way the application of the doctrine of equivalents.

CLAIMS

1. A process for forming thermoplastic products having precise embossed surfaces comprising the steps of:

providing a continuous press;

passing a thermoplastic material through said press;

heating said material to about 480 degrees F.;

applying a pressure of about 250 psi to said material;

providing upper and lower belts with predetermined patterns;

applying the pressure to said material through said belts;

cooling said material to about 35 degrees F.; and

maintaining pressure on said material when said material is cooled.

2. A process as claimed in claim 1 including the step of:

providing a reaction zone of about 78 inches by about 51 inches for the heating and pressure applying steps.

3. A process as claimed in claim 2 wherein:

the step of passing said material through the press is at a rate between about 21 and about 32 feet per minute.

4. A process for forming thermoplastic products having precise embossed surfaces comprising the steps of:

providing a continuous press;

passing a thermoplastic material through said press;

heating said material to approximately 250° to 580° F.;

providing upper and lower belts on said press, at least one of said belts having a predetermined pattern to be embossed;

applying pressure of about 150 to 400 psi through said belts to said material at the same time as said material is heated;

cooling said material; and

maintaining pressure of said material when said material is cooled.

5. A process as claimed in claim 4 wherein:

the cooling step includes the provision of a cooling station and maintaining said station at between 32° to 40° F.

6. A process as claimed in claim 5 wherein:

said maintaining step when cooling includes maintaining pressure at about 150 psi to about 400 psi.

7. An apparatus for making thermoplastic products having precise embossed surfaces comprising in combination:

a press having an upper set of rollers, a lower set of rollers, an upper belt disposed about said upper set of rollers, a lower belt disposed about said lower set of rollers, a heating station disposed adjacent said upper and lower belts, a cooling station adjacent said upper and lower belts and said heating station, and pressure producing elements disposed adjacent said upper and lower belts;

said heating station having a length of about seventy-nine inches;

said cooling station having a length of about thirty-nine inches;

said pressure producing elements producing a pressure of about 250 psi;

said heating station being heated to about 480 degrees F.; and

said cooling station being maintained at about 35 degrees F.

8. An apparatus as claimed in claim 7 including:

a reaction zone operatively connected to said press, said zone being about 78 inches by about 51 inches.

9. An apparatus for making thermoplastic products having precise embossed surfaces comprising:

a continuous press having a heating station capable of heating a product within a range of approximately 250 to 580 degrees F.;

means for applying pressure within the range of 150 to 400 psi at the same time as the product is heated; and

a cooling station having the capability to maintain the product at between 32 to 40 degrees F.

10. An apparatus as claimed in claim 9 including:

means for maintaining a pressure from about 150 psi to about 400 psi in said cooling station.

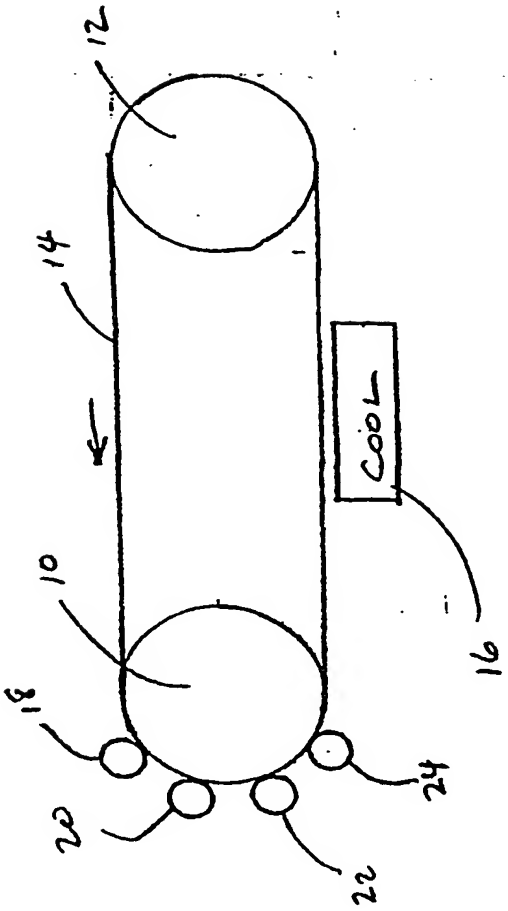


Fig 1

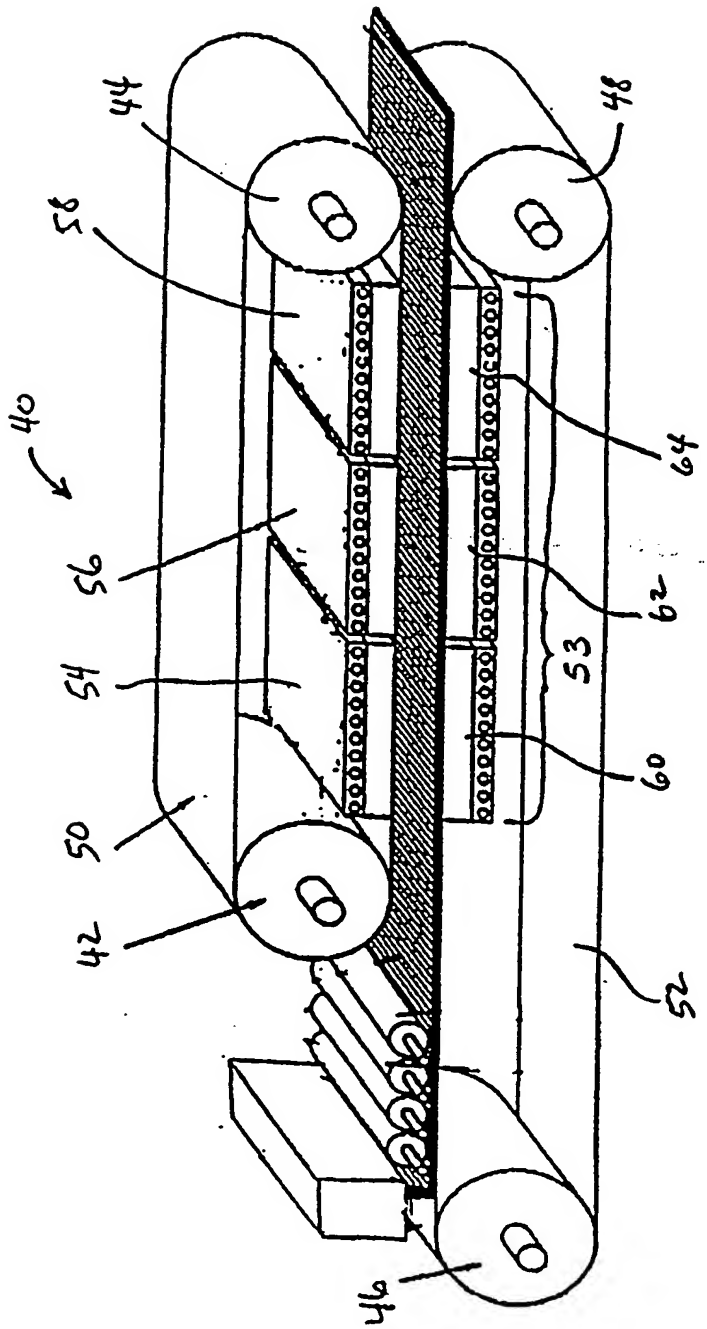
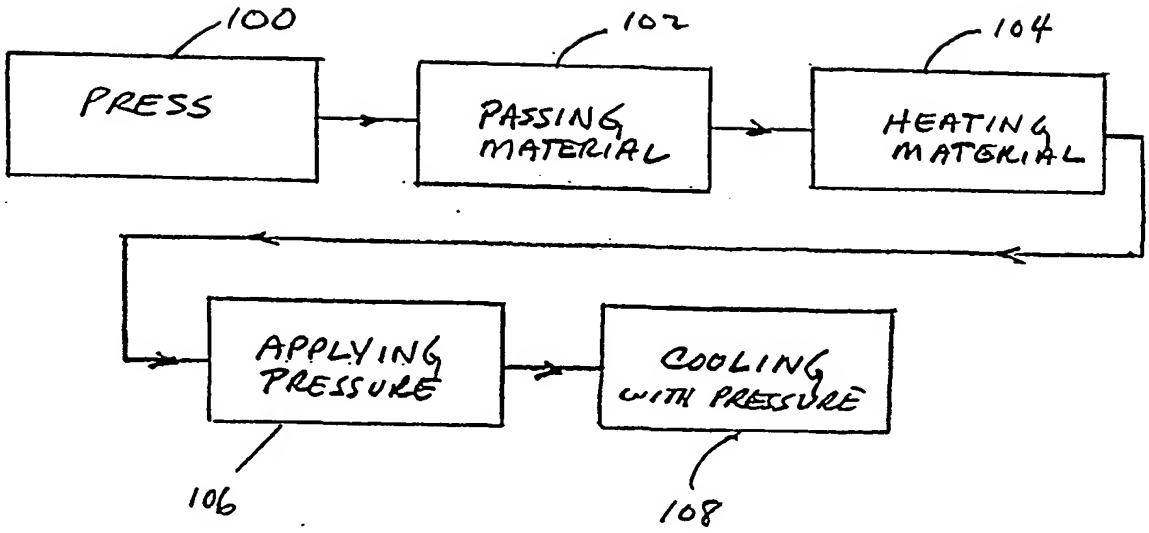


Fig 2

FIG 3


100
PRESS
102
PASSING MATERIAL
104
HEATING MATERIAL
APPLYING PRESSURE
106
COOLING WITH PRESSURE
108

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/18655

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B29D 11/00; B29C 59/04
US CL : 264/1.6, 1.9, 284, 293; 425/371, 384, 385

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 264/1.6, 1.9, 284, 293; 425/371, 384, 385

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,844,766 A (HELD) 04 July 1989 (04.07.1989); title; abstract; column 2, lines 12-19; column 3, lines 48-65; column 5, lines 3-9 and 43-68; column 6, lines 29-49; Figures.	1-10
Y	US 4,486,363 A (PRICONE et al) 04 December 1984 (04.12.1984); column 2, line 57 - column 3, line 25; column 6, lines 48-68; column 7, lines 37-48; column 8, lines 15-21.	1-10
A	US 3,901,639 A (MANDELSON et al) 26 August 1975 (26.08.1975); entire document.	1-10
A	US 4,332,847 A (ROWLAND) 01 June 1982 (01.06.1982); entire document.	1-10
A	US 4,396,566 A (BRINKMANN et al) 02 August 1983 (02.08.1983); entire document.	1-10
A	US 5,211,899 A (FUJII) 18 May 1993 (18.05.1993); entire document.	1-10
A	US 5,958,309 A (FUJII et al) 28 September 1999 (28.09.1999); entire document.	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
27 August 2001 (27.08.2001)

Date of mailing of the international search report
18 OCT 2001

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Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/18655

Continuation of B. FIELDS SEARCHED Item 3:

BRS

search terms: band, belt, press, emboss$5, heat$3, cool$3, reaction, thermoplastic, plastic, deformable, reaction zone, retroreflective, acrylic, polycarbonate, $4vinyl, polyethylene, ABS, polyurethane, temperature, pressure